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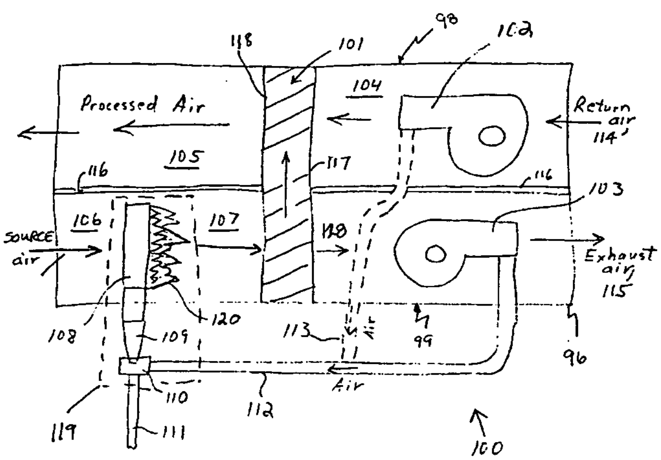
(54) Title: DESICCANT DEHUMIDIFICATION SYSTEM



(57) **Abstract:** A desiccant dehumidification system (DDS) uses an air heater that incorporates air feedback from the exhaust and/or the return air fans. The air and gas are mixed in a mixing valve. The mixing valve may be a single step, a two step or a continuous modulation valve. An outdoor cooking grille style burner allows a small unit to be made with tight air heating controls. The desiccant dehumidification system is combined into two desiccant air conditioning systems. One system cools the return air making it cool and humid. A portion of this air is then dried by a DDS which makes output air that is hot and dry. The remaining return air is mixed with the DDS output air to deliver processed air in a controlled comfort range. A second system mixes return air with fresh air to make mixed return air which is dried in a DDS. The dried return air is then cooled to a desired comfort range without condensation.

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DESICCANT DEHUMIDIFICATION SYSTEM

TECHNICAL FIELD

The present invention relates in general to systems for removing humidity from the air while maintaining a desired comfort factor corresponding to a desired combination of temperature and humidity.

BACKGROUND OF THE INVENTION

It has always been a desire to manipulate atmospheric conditions for comfort and to meet specific conditions required for certain facilities. Typically, these prior art systems have directly heated or cooled the outside air or air return from a structure and then exhausted the air into the structure. One of the effects of heating or cooling an air stream is the resulting change in the moisture content of the air. It is well recognized that the comfort of a structure is not only dependent on the temperature of the atmosphere but also on the humidity level. It is also desired to maintain specific temperature and/or humidity levels in structures.

There is a need for an economical and efficient system that can treat air to achieve a determined zone of humidity and temperature within a structure and/or within a zone of a structure. The present invention provides a system for conditioning air that meets these demands in an economical and efficient manner.

SUMMARY

A desiccant dehumidification system of the type for reducing the moisture content of a stream of air to be exhausted to an area is provided. The desiccant dehumidification system includes a housing partitioned into a first and a second air chamber for passing air therethrough. A desiccant wheel is rotatably positioned across both air chambers in a manner such that moisture is removed from the air stream in the first chamber and moisture is removed from the desiccant wheel by an air stream in the second chamber. The second chamber further includes an air heater positioned to heat the air stream before passing across the desiccant wheel to remove moisture therefrom. The air heater is charged with a slip stream, or portion of the air stream, passing through the first air chamber and/or the second air chamber.

The air heater may be a fuel fired burner wherein the heater may be further controlled by the introduction of air from the first air chamber and/or the second air chamber. Utilization of a portion of air energized within one or both of the air chambers increases the efficient of the present invention reducing energy costs and increasing energy conservation.

The present invention may further include a mixing of return air from a structure and fresh air. The system of the present invention may further include cooling and/or heating mechanisms upstream of the dehumidification station or after the dehumidification station.

The system of the present invention may be utilized as a stand alone system for conditioning of air or in conjunction with current air conditioning systems to further control the desired conditions of an atmosphere.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of a desiccant dehumidification system (DDS) according to an embodiment of the present invention;

FIG. 2 is a block diagram of a desiccant air conditioning system (DACS) according to an embodiment of the present invention where return air is mixed with conditioned air to create air for a living space; and

FIG. 3 is a block diagram of a DACS according to an embodiment of the present invention where fresh air is mixed with return air to generate air that is further conditioned to create air for a living space.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of the present invention. However, it will be obvious to those skilled in the art that the present invention may be practiced without such specific details. In other instances, well-known mechanical sub-systems have been shown in block diagram form in order not to obscure the present invention in unnecessary detail. For the most part, details concerning particular fan types, motors, valves and the like may have been omitted in as much as such

details are not necessary to obtain a complete understanding of the present invention and are within the skills of persons of ordinary skill in the relevant art.

Refer now to the drawings wherein depicted elements are not necessarily shown to scale and wherein like or similar elements may be designated by the same reference numeral through the several views.

FIG. 1 is a block diagram of a desiccant dehumidifying system (DDS) 100 according to one embodiment of the present invention. DDS 100 includes a housing 96 partitioned into two separate air chambers, a first air chamber 98 and a second air chamber 99, by partition 116. This ensures that the air in each partition are relatively separate during processing. Desiccant wheel 101 is rotated so that its surfaces 117 and 118 are exposed to the air in one or the other of the partitions determined by partition 116. Desiccant wheel 101 is a porous structure and is coated with a desiccant material that absorbs water from air passing over it.

Processed air 105 is delivered to some space (e.g., a living space) with an air condition depending on its use. Return air 114 is air that has been exposed to the environment of the living space and is being returned to DDS 100 to be re-conditioned. Fan 102 pulls in return air 114 and forces it as pressurized return air 104 through desiccant wheel 101 from surface 117 to surface 118 where it exits as processed air 105. During this process, desiccant wheel 101 takes moisture out of pressurized return air 104. As moisture is taken from pressurized return air 104, its temperature rises and its relative humidity drops (energy is removed from the air). Processed air 105 has less humidity and a higher temperature than pressurized return air 104.

Source air 106 is air that is separate from return air 114 and processed air 105, for example it may be outside environment air. Fan 103 creates a pressure drop across the lower half of desiccant wheel 101 in the partition of DDS 100 below partition 116. This draws source air 106 into the section of DDS 100 below partition 116. Air heater 119 comprises a burner 108 with a gas (combustible) inlet line 111 and a gas/air mixing unit 110. The gas in gas line 111 is pressurized and is mixed with air from air line 112. The mixing may be done two ways. Mixing unit 110 may be simply a chamber that uses the action of venturi 109 to "pull" air from air line 112. Alternately, mixing unit 110 may comprise a controllable mixing valve (not shown). If mixing unit 110 is a mixing valve it may be a single step, a two step or a continuous modulation valve. Burner 108 has an igniter (not shown) for lighting the gas/air mixture from mixing unit

110 as it exits the jets of the burner creating flame 120. Burner 108 may be designed to operate like a burner for an outdoor cooking grill.

Source air 106 is heated and becomes heated source air 107 as it passes through burner 108. Heated source air 107 passes through the portion of desiccant wheel 101 that has absorbed water from the return air 104. The heated source air 107 picks up moisture from desiccant wheel 101 creating exhaust air 128 (cooler and wetter than heated source air 107) which fan 103 delivers as exhaust air 115. The portion of desiccant wheel 101 that has had moisture removed by heated source air 107 returns to the return air stream hotter and dryer to again pick up moisture from return air 104.

Fan 102 may have a portion of its return air 104 channeled with air line 113 back to air line 112 which may also receive air from exhaust air 115 via fan 103. For burner 108 to operate, the gas in gas line 111 must be mixed with air to enable combustion to take place. DDS 100 "super charges" the air stream for combustion by combining a portion of the pressurized return air 104 and/or pressurized exhaust air 115. If more volume of processed air 105 is required, then naturally burner 108 would have to be turned up along with increasing the speeds of fans 102 and 103. The air volume for burner 108 from line 112 would likewise increase resulting in regulation of burner 108.

FIG. 2 is a diagram of a desiccant air conditioning system (DACS) 200 that operates according to another embodiment of the present invention. DACS 200 has three major sections; return air cooler 201, desiccant dehumidifying system (DDS) 202, and air delivery duct 207.

Return air cooler 201 has a chamber 203 and a chamber 205 separated by an evaporative cooler 204. Fan 206 is coupled to air delivery duct 207 and pulls air from the return air 220 and pressurizes it and delivers it to air delivery duct 207 as pressurized return air 221. DDS 202 is coupled to air delivery duct 207 with duct 208 and duct 213. A portion of pressurized return air 221 is channeled through duct 208 as the input air 222 to DDS 202. DDS 202 operates the same as DDS 101 described relative to FIG. 1. Desiccant wheel 210 rotates between the partitions of DDS 202 determined by partition 227. The upper partition is further divided by desiccant wheel 210 into chambers 209 and 211. Fan 212 pulls input air 222 into chamber 209 across desiccant wheel 210 that removes moisture and raises the temperature of output air 223. Output air 223 is delivered back to air delivery duct 207 where it is mixed with air 224 to form processed air 214 for the living space 230.

Source air 225 is heated by air heater 216 in chamber 215. Heated air 228 passes through desiccant wheel 210 where it picks up moisture that desiccant wheel 210 extracted from input air 222. This humid air exits from chamber 218 as exhaust air 226.

Return air conditioner 201 takes return air 220 which is warm with a certain relative humidity and delivers pressurized return air 221 which is cooler with a higher relative humidity. DDS 202 then dries a portion of pressurized return air 221 (input air 222) and delivers it as output air 223 which is hot dry air. The remaining air 224 (cool and humid) is mixed with output air 223 (hot and dry) to deliver processed air 214 which is warmer and dry and is within a desired comfort zone. A controller (not shown) receives the temperature and relative humidity of processed air 214, return air 220, and output air 223 to adjust parameters of DACS 200 (e.g., fan 212 speed, heater 216 temperature, fan 229 speed, fan 206 speed, etc.) to control the temperature and humidity for the processed air 214. Processed air 214 is delivered at a comfort level using less energy than is possible with a standard air condition system.

FIG. 3 is another hybrid desiccant air conditioning system (HDACS) 300 according to embodiments of the present invention. HDACS 300 has two primary sections, air mixing chamber 302 and desiccant air conditioning system (DACS) 301. Mixing chamber 302 receives return air 315 and fresh air 314 and mixes them to form mixed air 316 which is delivered to chamber 303 in DACS 301. Partition 313 separates DACS 301 into a desiccant dryer section with chambers 310, 311, 303 and 305 and cooling section with shared chamber 305 and chamber 307. Desiccant wheel 304 operates across partition 313 that separates the return air stream from the source/exhaust air stream. Fan 308 is the air mover for the section above partition 313.

Air mixing chamber 302 allows a measured portion of outside fresh air 314 to be mixed with the return air 315 to control the air exchange rate for the living space 330. Fan 308 pulls mixed air 316 through desiccant wheel 304 which extracts moisture delivering input air 317 which is hotter and dryer than mixed air 316. Exhaust fan 312 pulls source air 319 into chamber 310 where it is heated with air heater system 309 delivering output air 320 which is hot and dry. Output air 320 is pulled through desiccant wheel 304 where it extracts moisture from the desiccant and exits into chamber 311. The air in chamber 311 is removed by fan 312 as exhaust air 320. Exhaust air 321 is cooler and more humid than output air 320.

Mixed air 316 undergoes a desiccant drying cycle which removes energy from the air and delivers output air 317 which is hotter and dryer. Output air 317 is then pulled through

evaporative cooler 306 which simply cools output air 317 and delivers it to chamber 307. The air from chamber 307 is then delivered to living space 330 as processed air 318. The cooling of output air 317 decreases the temperature of the air and increases its relative humidity. The air processing cycle achieved with HDACS 300 uses less energy than conventional air conditioning systems and results in a system having no condensation. Air heater system 309 may operate the same as air heater system 119 as described relative to FIG. 1. If air system 309 uses a burner like burner 108, then air feedback could be coupled from fan 308 and 312 with corresponding air lines (e.g., like 113 and 112 respectively).

U.S. Patent 5,373,704, to *McFadden* may also provide exemplary procedural and/or other details supplementary to the above disclosure, and are specifically incorporated herein by reference.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A desiccant dehumidification system comprising:

a housing partitioned into a first and second air chamber each for passing air therethrough, each said air chamber having an inlet for intake of air and an outlet for exhausting of air;

a rotating desiccant wheel positioned inside said housing and across said air chambers;

an air transmitting means positioned within said first air chamber for drawing return air from a structure into said first air chamber and passing said air across said desiccant wheel to remove moisture from said return air and exhausting into the structure as conditioned air;

an air transmitting means positioned within said second air chamber for drawing a source air into said second air chamber, across said desiccant wheel to remove moisture from said desiccant wheel and exhausting from said second air chamber;

an air heating means positioned in said second air chamber upstream of said desiccant wheel for heating said source air to be passed over said desiccant wheel; and

a conduit in operational connection between at least one said air transmitting means and said air heating means for passing pressurized air to said air heating means.

2. The desiccant dehumidification system of claim 1 wherein said conduit is in operational connection between said air transmitting means in said first air chamber and said air heating means for passing pressurized return air to said air heating means.

3. The desiccant dehumidification system of claim 1 wherein said conduit is in operational connection between said air transmitting means in said second air chamber and said air heating means for passing pressurized source air to said air heating means.

4. The desiccant dehumidification system of claim 1 wherein said conduit is in operational connection between said air transmitting means in said first air chamber and said air heating means for passing pressurized return air to said air heating means and said air transmitting means in said second air chamber and said air heating means for passing pressurized source air to said air heating means.

5. A desiccant air cooling system, said desiccant air cooling system comprising:

an air cooling means for cooling a return air from a structure and recirculating the cooled returned air to the structure; and

a desiccant dehumidification system comprising:

a housing partitioned into a first and second air chamber each for passing air therethrough, each said air chamber having an inlet for intake of air and an outlet for exhausting of air;

a rotating desiccant wheel positioned inside said housing and across said air chambers;

an air transmitting means positioned within said first air chamber for drawing a portion of said cooled return air into said first air chamber and passing said cooled return air across said desiccant wheel to remove moisture from said cooled return air and exhausting into the structure as conditioned air;

an air transmitting means positioned within said second air chamber for drawing a source air into said second air chamber, across said desiccant wheel to remove moisture from said desiccant wheel and exhausting from said second air chamber; and

an air heating means positioned in said second air chamber upstream of said desiccant wheel for heating said source air to be passed over said desiccant wheel.

6. The system of claim 5 further including a conduit in operational connection between at least one said air transmitting means and said air heating means for passing pressurized air to said air heating means.

7. The system of claim 6 wherein said conduit is in operational connection between said air transmitting means in said first air chamber and said air heating means for passing pressurized return air to said air heating means.

8. The system of claim 6 wherein said conduit is in operational connection between said air transmitting means in said second air chamber and said air heating means for passing pressurized source air to said air heating means.

9. The system of claim 6 wherein said conduit is in operational connection between said air transmitting means in said first air chamber and said air heating means for passing pressurized return air to said air heating means and said air transmitting means in said second air chamber and said air heating means for passing pressurized source air to said air heating means.

10. A desiccant air cooling system, said desiccant air cooling system comprising:

an air mixing means for mixing a return air from a structure with a fresh air to form a mixed air;

a housing partitioned into a first and second air chamber each for passing air therethrough, each said air chamber having an inlet for intake of air and an outlet for exhausting of air;

a rotating desiccant wheel positioned inside said housing and across said air chambers;

a cooling means positioned within said first air chamber;

an air transmitting means positioned within said first air chamber for drawing said mixed air into said first air chamber and passing said mixed air across said desiccant wheel to remove moisture from said mixed air, across said cooling means and exhausting into the structure as conditioned air;

an air transmitting means positioned within said second air chamber for drawing a source air into said second air chamber, across said desiccant wheel to remove moisture from said desiccant wheel and exhausting from said second air chamber; and

an air heating means positioned in said second air chamber upstream of said desiccant wheel for heating said source air to be passed over said desiccant wheel.

11. The system of claim 5 further including a conduit in operational connection between at least one said air transmitting means and said air heating means for passing pressurized air to said air heating means.

12. The system of claim 11 wherein said conduit is in operational connection between said air transmitting means in said first air chamber and said air heating means for passing pressurized return air to said air heating means.

13. The system of claim 11 wherein said conduit is in operational connection between said air transmitting means in said second air chamber and said air heating means for passing pressurized source air to said air heating means.

14. The system of claim 11 wherein said conduit is in operational connection between said air transmitting means in said first air chamber and said air heating means for passing pressurized return air to said air heating means and said air transmitting means in said second air chamber and said air heating means for passing pressurized source air to said air heating means.

15. A method of reducing the humidity of air to maintain a desired humidity and temperature of air in a structure comprising the steps of:

drawing return air from a structure into a first air chamber;

passing said return air across a portion of a desiccant wheel removing moisture from said return air;

exhausting said return air as conditioned air into the structure;

drawing a source air into a second air chamber;

passing said source air through a gas fired heater to heat said source air;

passing said heated source air across a portion of said desiccant wheel removing moisture from said desiccant wheel;

exhausting said source air from said second chamber; and

charging said gas fired heater with an air stream from at least one of said first or said second air chamber.

16. The method of claim 15 wherein said air heater is charged by an air stream from said first air chamber.

17. The method of claim 15 wherein said air heater is charged by an air stream from said second air chamber.

18. The method of claim 15 wherein said air heater is charged by an air stream from said first air chamber and an air stream from said second air chamber.

19. The method of claim 15 further including the step of cooling said return air before passing through said desiccant wheel.

20. The method of claim 16 further including the step of cooling said return air before passing through said desiccant wheel.

21. The method of claim 17 further including the step of cooling said return air before passing through said desiccant wheel.

22. The method of claim 18 further including the step of cooling said return air before passing through said desiccant wheel.

23. The method of claim 15 further including the step of mixing said return air with fresh air before transmitting said return air through said first chamber.

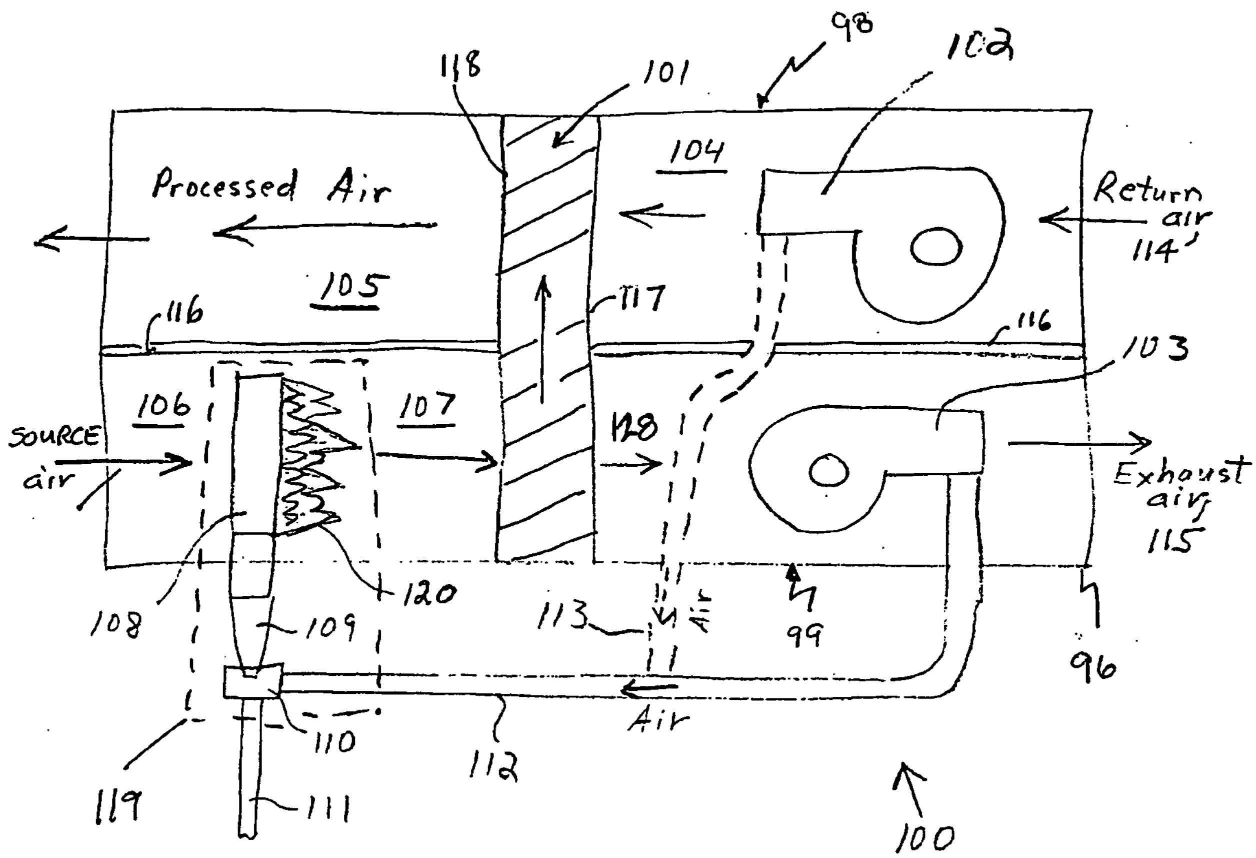
24. The method of Claim 153 further including the step of cooling said return air after passing through said desiccant wheel and before being exhausted into the structure.

25. The method of Claim 23 further including the step of cooling said return air after passing through said desiccant wheel and before being exhausted into the structure.

26. The method of claim 25 wherein said air heater is charged by an air stream from said first air chamber.

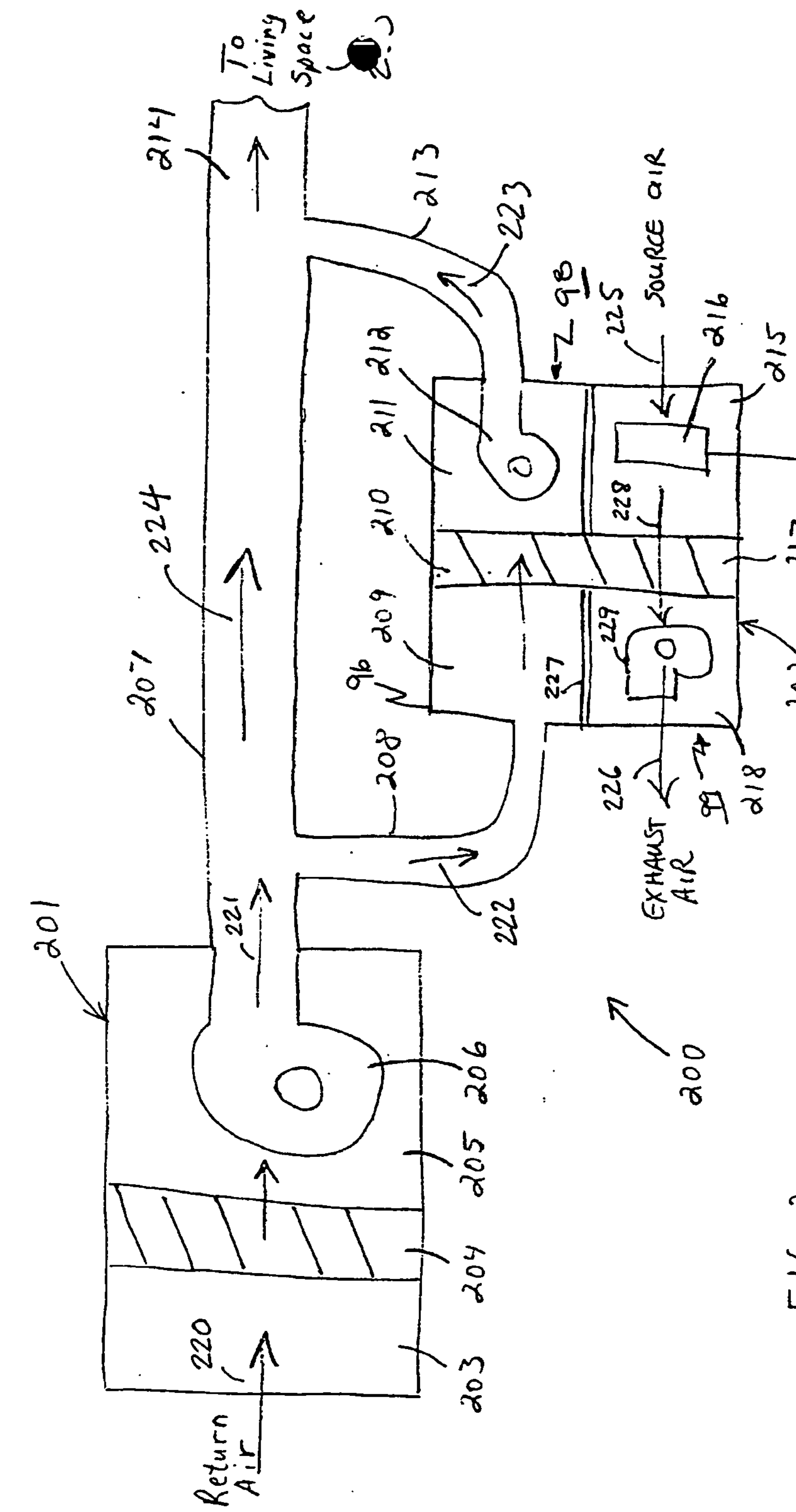
27. The method of claim 25 wherein said air heater is charged by an air stream from said second air chamber.

28. The method of claim 25 wherein said air heater is charged by an air stream from said first air chamber and an air stream from said second air chamber.



98
102
118
101
104
Processed Air
Return air 114'
105
116
117
116
103
106
107
SOURCE air
128
Exhaust air 115
108
120
109
113
Air
99
96
110
112
Air
119
111
100

FIG. 1


To Living Space
Return Air
SOURCE AIR
EXHAUST AIR
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202
203
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206
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208
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210
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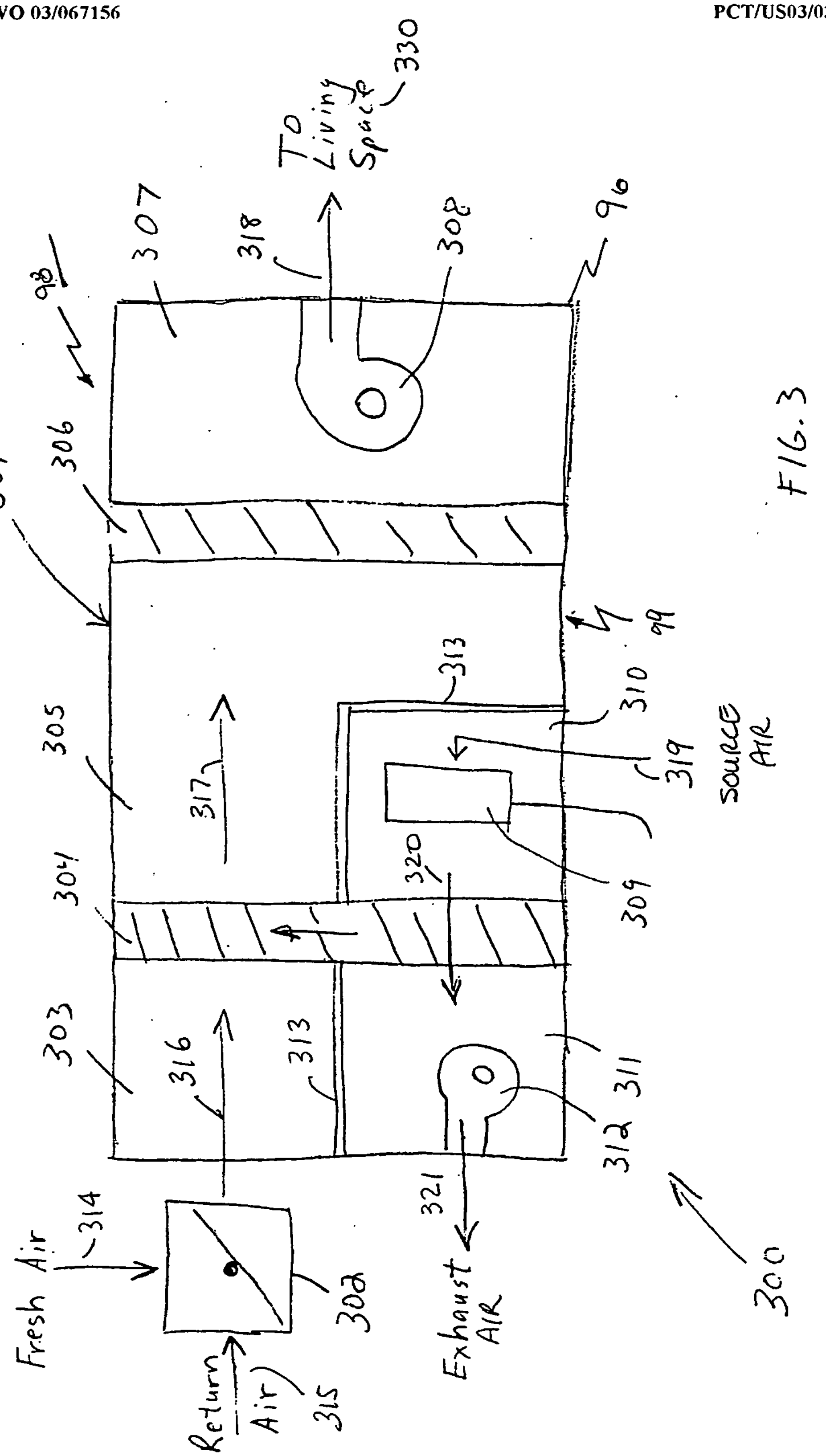
229
96
98
99

FIG. 2


To Living Space
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318
308
98
96
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305
317
313
310
319
SOURCE AIR
99
309
304
320
303
316
313
311
312
321
Fresh Air
314
302
Return Air
315
Exhaust AIR
300

FIG. 3